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(54) Abstract Title

Reducing transmission power in response to a detected decrease in available battery power

(57) A mobile communication device, which may be a mobile telephone, comprising means to detect a reduction in the available battery power by detecting a corresponding reduction in its transmit power. In response, if a reduction is detected, the device sets its transmit power to a reduced second level which will take less current from the battery and therefore prolong the life of the battery. Furthermore this process may be repeated and the transmit power may be reduced in steps of about 2 dB to lower the transmit power level each time a further reduction in the available battery power is detected. To detect the reducing transmit power the device may monitor a feedback signal 21 from the transmitter 19 and use a comparator 15 to determine a reduction in the transmit power. The device may also comprise means to deny a request from an external system to increase the transmit power. The device may also provide a visual or audio alert that the transmit power has been set to a lower level.

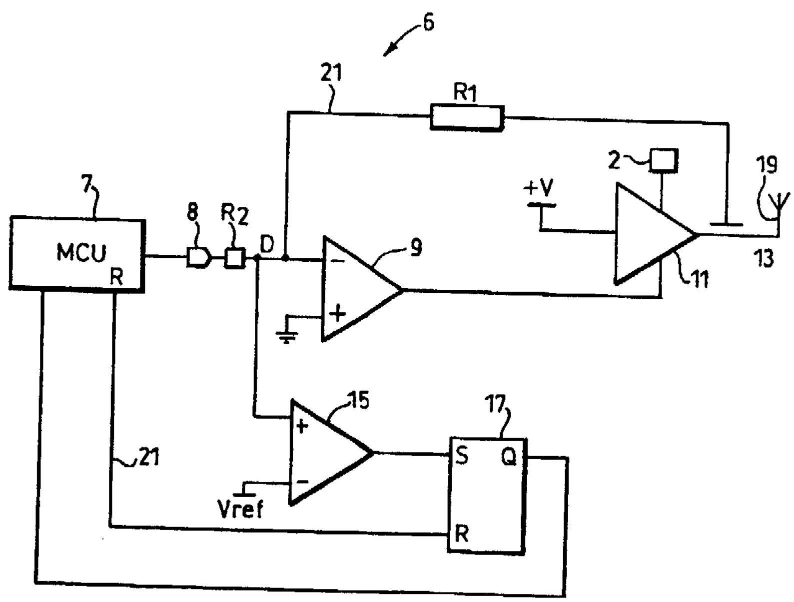

FIG.2.

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

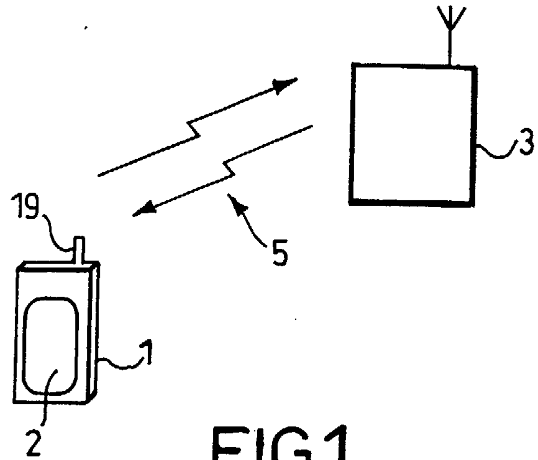

FIG.1.

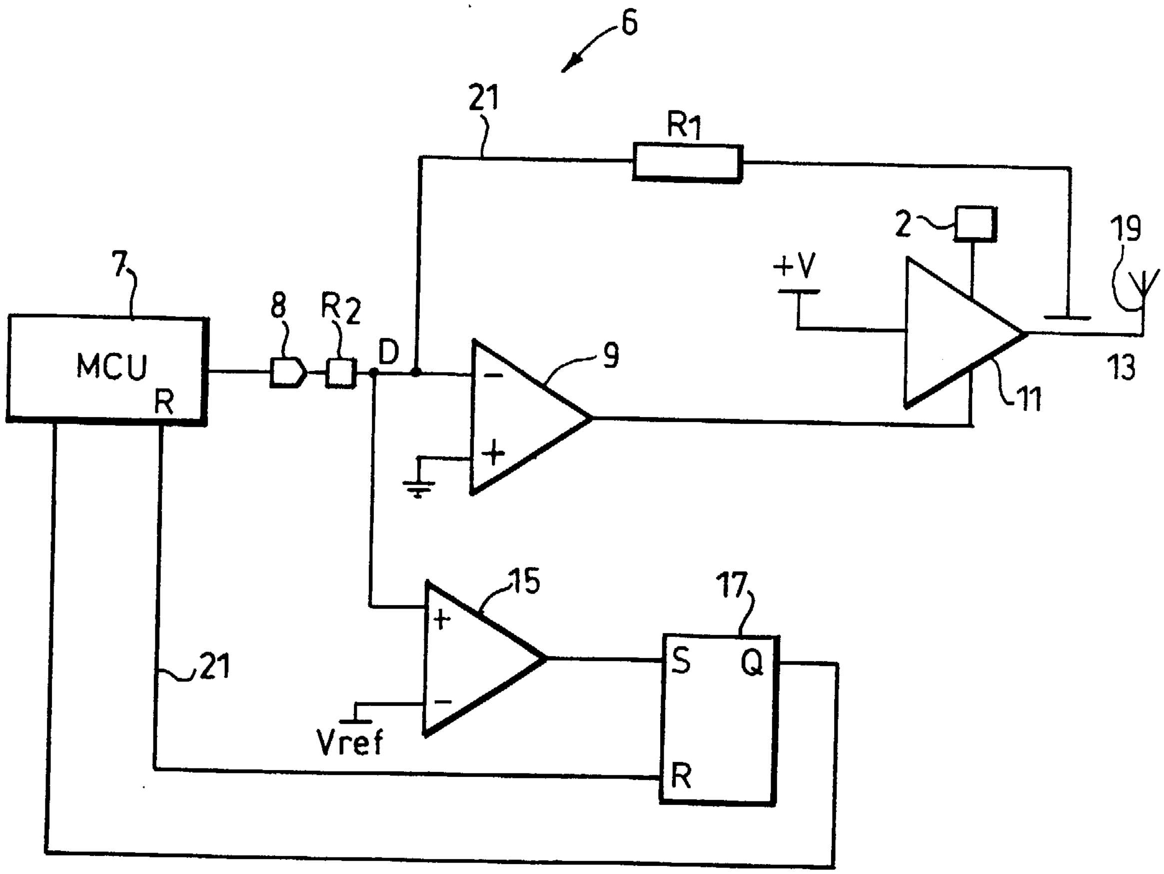

FIG.2.

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A Mobile Communications Device

This invention relates to a mobile communications device, and particularly to a battery-powered mobile communications device. The invention also relates to a method of controlling the transmission power of a battery-powered mobile communications device.

Mobile communications devices, such as mobile telephones, personal digital assistants (PDAs) and so on, are becoming increasingly popular. This is principally due to the fact that they can be battery-powered and so are portable. One of the main problems associated with such battery-powered devices is the limited time over which sufficient power can be supplied by the battery before it needs recharging. As the battery power becomes low, it is normal to warn a user of the communications device (e.g. by an audible alarm) so that use of the device can be terminated. Shortly after the warning, the communications device is usually configured to shut down completely. In the case of a mobile telephone, this often results in calls being dropped.

Conventionally, the voltage of the battery is used to determine the level at which the user is warned of a low battery level, and the level at which the communications device is shut down. This is non-optimal since different batteries will have different characteristics, some of which may vary with other factors such as temperature. Therefore, the voltage level at which the warning and shut down event occurs is often predefined at a level which is higher than the minimum level at which the battery can actually maintain the transmit power to a useful level.

According to one aspect of the present invention, there is provided a mobile communications device comprising: a battery; a transmitter; and a power control circuit; wherein the power control circuit is arranged to set the transmit power from the transmitter to a first level, to detect a reduction in the available battery power by means of detecting a resultant reduction in the transmit power; and, in response to the detected reduction in transmit power, to set the transmit power to a second level which is less than that of the first level.

Accordingly, the device monitors the transmit power (which may be initially set to the first level by a mobile communications network) and, when the degrading battery power causes the transmit power to reduce, the device is then intentionally configured to reduce the transmit power to a second, lower level. This has the effect that the amount of current taken by the transmitter is reduced, and so the battery voltage will increase. The overall effect is that the remaining life of the battery will be extended. The second level should be set to allow the communications device to maintain a connection over the mobile network, e.g. with a base station, so that use of the device can continue.

In the preferred embodiment, the power control circuit comprises a comparator and a power controller, the comparator being arranged to monitor a feedback signal from the transmitter and to output a control signal to the power controller, the power controller being arranged to reduce the transmit power from the first level to the second level in response to the control signal. The power control circuit may further comprise a latch between the comparator and the power controller, the latch being arranged to receive the control signal from the comparator, and to output a latched version of the control signal to the power controller.

The power controller preferably comprises a microcontroller unit which is configured to set the transmit power at the first level, and to the reduce the transmit power to the second level in response to receiving the control signal from the comparator. The microcontroller unit may be easily programmed, e.g. with the first and second levels.

The mobile communications network may command an increase in the transmit power of the communications device in response to network receiving a signal at the reduced (second) transmit power level. This is how conventional mobile telephone base stations work, i.e. in an attempt to maintain a particular transmit power level if the signal becomes unintentionally degraded, e.g. if the user goes through a built-up area. In this case, however, the reduction in transmit power is intentional and so the power control circuit is preferably arranged to deny a request to increase the transmit power from a system external to the mobile communications device.

The power control circuit may be further arranged to detect a further reduction in the available battery power by means of detecting a resultant further reduction in the transmit power, and, in response to the detected further reduction in transmit power, to set the required transmit power to a third level which is less than that of the second level. In effect, the power control circuit may continue to decrease the transmit power in predefined steps in accordance with the reducing battery voltage causing a reduction in the transmit power from its current setting. As such, the user may continue to use the communications device for longer, or until the signal becomes so degraded that the link being utilised is effectively useless. The overall effect, however, will be a prolonged and more efficient use of the available battery power.

The difference between the first level and the second level, or between the second level and the third level, is preferably in the region of 2dB. The power control circuit may be arranged to output a visual or audio alert in the event of transmit power being reduced by the power control circuit.

The device finds particular application is provided in the form of a mobile telephone, for example, a GSM telephone.

According to a second aspect of the invention, there is provided a method of controlling the transmission power of a battery-powered mobile communications device, the method comprising: monitoring the transmission power of the communications device to determine when the transmission power falls below a first predetermined level due to a reduction in battery power; and automatically reducing the transmission power to a second predetermined level in response to the detected fall.

The invention will now be described, by way of example, with reference to the accompanying drawings in which:

Figure 1 shows a communications link including a GSM mobile telephone; and

Figure 2 is a diagram showing the elements in a circuit of the GSM mobile telephone in Figure 1 .

Referring to Figure 1, a simple communications link between a GSM telephone 1 (hereinafter referred to simply as "the telephone") and a cellular network base station 3 is shown. The telephone 1 is powered by a battery 2, e.g. a lithium ion battery. The communications link is represented generally by the reference numeral 5. The base station 3 is one of a large number of such base stations making up a GSM network.

The GSM network acts to control the transmit power of the telephone 1 via the base station 3. The base station 3 initially commands the telephone 1 to use a specified transmit power level. When the telephone 1 is used for a call, close loop power control is used to maintain a particular level of service. In other words, the base station 3 monitors the signal being received from the telephone 1, and commands the telephone to increase or decrease its transmit power in increments of 2dB according to the magnitude of the receiver signal. This acts to maintain a particular level of service between the telephone 1 and the base station 3, e.g. by increasing the transmit power if the signal is degraded, for example by terrain.

Figure 2 shows elements of a circuit 6 making up the overall circuitry of the telephone 1. The main elements of the circuit 6 are a battery 2, a microcontroller unit (MCU) 7, a digital-to-analogue convertor (DAC) 8, an amplifier 9, a power amplifier 11, an r.f. coupler 13, a comparator 15 and a latch in the form of a reset-set (RS) flip-flop 17. The battery 2 provides power to the power amplifier 11 which drives the antenna 19 via the r.f. coupler 13. The MCU 7 provides digital control over the level of the transmit signal, including setting the initial level commanded by the base station 3. DAC 8 converts to an analogue signal a power control signal which is input to the amplifier 9, via a resistor R2, the output of which is used as a control signal to the power amplifier 11. A feedback path 21 is provided from the output of the power amplifier 11, via the r.f. coupler 13 and a resistor R1, to the input of the amplifier 9 at a node D. The comparator 15 receives the signal at the node D, and outputs a "high" signal if the signal at D is greater than a reference voltage Vref at the negative terminal. The output from the comparator 15 is input to the RS flip-flop 17, the output terminal of which is connected to the MCU 7. A reset line 21 connects an output pin (R) of the MCU 7 and a reset pin of the RS flip-flop 17.

In use, the telephone 1 uses closed loop power control to ensure that its transmitter is outputting the required transmit power level. Initially, this is the level commanded by the base station 3, the MCU 7 outputting the appropriate power control signal via DAC 8 and R2 to the amplifier 9 which sets the power amplifier 11 accordingly. A small proportion of the output power is fedback via the feedback path 21 to the node D at the negative terminal of the amplifier 9. Under normal conditions, the difference between the signal from the MCU 7 and the fedback signal will be zero, and so the power level is maintained at the required transmit level for as long as it required to do so.

The amplifier 9 is monitored by the comparator 15 (more particularly, the signal at the node D is monitored by the comparator, the signal at the node D representing the difference between a proportion of the transmit power output from the power amplifier 11 and the demanded power). As the battery voltage falls, the difference between the signal from the MCU 7 and the fedback signal becomes non-zero, and is detected by the comparator 15. The output from the comparator 15 is latched by the RS flip-flop 17 which outputs a "high" signal from its output pin Q. Since the output from the comparator 15 is likely to be transitory, use of the RS flip-flop 17 captures any high signal from the comparator.

The MCU 7 regularly checks the state of the Q output on the RS flip-flop 17. In response to this "high" signal, the MCU 7 is programmed to reduce the transmit power level by outputting a modified power control signal for controlling the power amplifier 11 accordingly. Here, the transmit power is reduced by 2 dB. Preferably, it is at this time that the audible and/or visual warning is given to the user to indicate that the battery voltage has fallen below a predetermined threshold. The MCU 7 also outputs a reset signal from its reset pin to reset the RS flip-flop 17 so that the Q output is low once again.

As far as the base station 3 is concerned, the telephone 1 is still signalling that it is transmitting the correct power (even though it has been reduced by 2dB). The reduction of 2dB results in a reduction of the current taken from the battery 2. This has the advantages that (i) the voltage at the power amplifier is increased, and (ii) the remaining charge in the battery will last longer than if the transmit power had not been reduced.

The reduction in transmit power will result in a reduction in received signal strength at the base station 3. As mentioned above, the base station 3 will attempt to increase the transmit power of the telephone 1 unless it is informed that the demanded power is already at its maximum level. Accordingly, the MCU 7 is programmed to effectively disable the power control by freezing the demanded power level at the last power level received from the base station 3, before the power level was reduced.

The above procedure is repeated again as the transmit power falls due to the battery charge running even lower. Again, the transmit power is reduced by a further 2dB, with a further warning being given to the user. This warning may be slightly different than that previously given so as to indicate the further reduction in battery power.

The reduced signal level at the base station 3 will result in a reduced signal to noise ratio (SNR) which may lead to a higher bit-rate error on the communications link 5 (the uplink only). Ultimately, as the transmit power decreases, this will lead to the communications link 5 being dropped. As is known to those skilled in the art, this occurs when the so-called frame erasure rate on the SACCH control channel of the communications link 5 approaches 70%. Before this point, the communications link 5 will be maintained, albeit with a reduced audio signal quality. However, such reduced signal quality is still highly preferable over the conventional system whereby the communications link 5 would have been dropped at a predetermined battery power level, regardless of the individual characteristics of the battery 2. Ultimately, the end result of the circuit 6 of the telephone 1 is to allow a gradual degradation of the service (on the uplink only) rather than the call simply ending.

Claims

1. A mobile communications device comprising: a battery; a transmitter; and a power control circuit; wherein the power control circuit is arranged to set the transmit power from the transmitter to a first level, to detect a reduction in the available battery power by means of detecting a corresponding reduction in the transmit power; and, in response to the detected reduction in transmit power, to set the transmit power to a second level which is less than that of the first level.

2. A mobile communications device according to claim 1, wherein the power control circuit comprises a comparator and a power controller, the comparator being arranged to monitor a feedback signal from the transmitter and to output a control signal to the power controller, the power controller being arranged to reduce the transmit power from the first level to the second level in response to the control signal.

3. A mobile communications device according to claim 2, wherein the power control circuit further comprises a latch between the comparator and the power controller, the latch being arranged to receive the control signal from the comparator, and to output a latched version of the control signal to the power controller.

4. A mobile communications device according to claim 2 or claim 3, wherein the power controller comprises a microcontroller unit which is configured to set the transmit power at the first level, and to reduce the transmit power to the second level in response to receiving the control signal from the comparator.

5. A mobile communications device according to any preceding claim, wherein the power control circuit is further arranged to deny a request to increase the transmit power from a system external to the mobile communications device.

6. A mobile communications device according to any preceding claim, wherein the power control circuit is further arranged to detect a further reduction in the available battery power by means of detecting a corresponding further reduction in the

transmit power; and, in response to the detected further reduction in transmit power, to set the required transmit power to a third level which is less than that of the second level.

7. A mobile communications device according to any preceding claim, wherein the difference between the first level and the second level, or between the second level and the third level, is in the region of 2dB.

8. A mobile communications device according to any preceding claim, wherein the power control circuit is arranged to output a visual or audio alert in the event of transmit power being reduced by the power control circuit.

9. A mobile communications device according to any preceding claim, the device being in the form of a mobile telephone.

10. A method of controlling the transmission power of a battery-powered mobile communications device, the method comprising: monitoring the transmission power of the communications device to determine when the transmission power falls below a first predetermined level due to a reduction in battery power; and automatically reducing the transmission power to a second predetermined level in response to the detected fall.

11. A mobile communications device constructed and arranged substantially as hereinbefore shown and described with reference to the accompanying drawings.

12. A method of controlling the transmission power of a battery-powered mobile communications device, substantially as hereinbefore described with reference to the accompanying drawings.

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Application No: GB 0112483.3
Claims searched: 1-12

Examiner: Adam Tucker
Date of search: 14 December 2001

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.S): H4L LDTP, LECTP, H3G PP

Int Cl (Ed.7): H04B 1/38, 1/40, 7/005, H04Q 7/32, H04M 1/73, G01R 19/165, H03G 3/20

Other: Online: WPI, EPODOC, PAJ and selected internet sites

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
Y	GB 2336047 A	(NEC) See in particular the abstract, page 17 line 7-page 18 line 7 and Fig. 2	1-10
Y	GB 2331648 A	(Motorola) See in particular page 10 lines 14-30	1-5, 8, 9, 10
Y	WO 00/59121 A1	(Ketonen) See in particular page 3 lines 17-21, page 18 lines 7-9	1-10
Y	US 4709404	(Tamura and Kimura) See in particular Fig 9, col 3 lines 15-37 and col 5 lines 1-11	1-10
Y	US 4521912	(Franke and Faulkenberry) See whole document	1-10
A	US 4199723	(Cummings and Sellmeyer) See in particular the abstract and abstract Figure	-
Y	JP 2000106605	(Denso) See enclosed PAJ translation, in particular the abstract, para 31-38 and drawing 1	1-10

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.